CLAIMS

1. A turbine engine component, comprising:

a substrate; and

an erosion resistant protective structure formed on the substrate, the erosion resistant protective structure comprising a shape memory alloy.

2. The turbine engine component of Claim 1, wherein the shape memory alloy is a component of a composite.

3. The turbine engine component of Claim 2, wherein the composite further comprises at least one hard particulate phase.

4. The turbine engine component of Claim 3, wherein the at least one hard particulate phase comprises a boride particulate, an oxide particulate, a nitride particulate, a carbide particulate, or combinations comprising at least one of the foregoing particulates.

5. The turbine engine component of Claim 2, wherein the composite comprises alternating layers of the shape memory alloy and a metallic or a ceramic layer.

6. The turbine engine component of Claim 5, wherein the metallic layer is selected from the group consisting of Ti, Ni, Co, Ti-based alloys, Ni-based alloys, Co-based alloys, and Fe-based alloys.

7. The turbine engine component of Claim 5, where in the ceramic layer is selected from the group consisting of borides, oxides, nitrides, carbides, TiN, Y_2O_3, and TaC.

8. The turbine engine component of Claim 2, wherein the composite further comprises grains having a grain size less than 2 micrometers.

9. The turbine engine component of Claim 1, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, ruthenium-niobium based alloys, ruthenium-tantalum based alloys, titanium based alloys, iron-based alloys, or combinations comprising at least one of the foregoing alloys.

10. The turbine engine component of Claim 1, wherein the shape memory alloy comprises a composition selected to exhibit an austenite phase at an environmental temperature in which the turbine engine component is disposed or operates and a martensite phase at about a temperature lower than the environmental temperature or operating temperature.

11. The turbine engine component of Claim 1, wherein the shape memory alloy comprises a composition selected to exhibit a superelastic phase at an environmental temperature in which the turbine engine component is disposed or operates and a martensite phase at about a temperature lower than the environmental temperature or operating temperature.

12. The turbine engine component of Claim 1, wherein the shape memory alloy comprises a composition selected to exhibit a martensitic phase at an environmental temperature in which the turbine engine component is disposed or operated.

13. The turbine engine component of Claim 1, wherein the substrate comprises a turbine nozzle, shroud, shroud hanger, bucket, airfoil, fan blades, pressure balance seal, or a combustor.

14. The turbine engine component of Claim 1,wherein the substrate comprises a superalloy.

15. The turbine engine component of Claim 1, wherein the substrate comprises a nickel-based or a cobalt-based superalloy, wherein the nickel or the cobalt element is at a higher amount by weight than other elements in the superalloy.

16. The turbine engine component of Claim 1, wherein the erosion resistant protective structure is formed on a portion of the substrate.

17. The turbine engine component of Claim 1,wherein the substrate comprises a ferritic-based alloy.

18. The turbine engine component of Claim 1, wherein the substrate comprises a titanium-based alloy.

19. The turbine engine component of Claim 1, further comprising a diffusion-controlling layer intermediate the shape memory alloy and the substrate.

20. A turbine engine component, comprising:

a substrate;

a diffusion-controlling layer affixed to the substrate; and

an erosion resistant protective structure affixed to the diffusion-controlling layer, wherein the erosion resistant protective structure comprises a shape memory alloy.

21. The turbine component of Claim 20, wherein the diffusion-controlling layer is a metal selected from the group consisting of pure metals or alloys that do not form brittle and/or low melting phases due to interaction with the erosion resistant protective structure or the substrate.

22. The turbine component of Claim 20, wherein the diffusion-controlling layer is a metal selected from the group consisting of Nb, Hf, Ta, and Zr.

23. The turbine component of Claim 20, wherein the substrate is an alloy selected from the group consisting of a nickel based alloy, a cobalt based alloy, a titanium based alloy, and a steel based alloy.

24. The turbine component of Claim 20, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, ruthenium-niobium based alloys, ruthenium-tantalum based alloys, titanium based alloys, iron-based alloys, or combinations comprising at least one of the foregoing alloys.

25. The turbine component of Claim 20, wherein the shape memory alloy comprises a composition selected to exhibit an austenite phase at an environmental temperature in which the turbine engine component is disposed or operates and a martensite phase at about a temperature lower than the environmental temperature or operating temperature.

26. The turbine component of Claim 20, wherein the shape memory alloy comprises a composition selected to exhibit an superelastic phase at an environmental temperature in which the turbine engine component is disposed or operates and a martensite phase at about a temperature lower than the environmental temperature or operating temperature.

27. The turbine engine component of Claim 20, wherein the shape memory alloy comprises a composition selected to exhibit a martensitic phase at an environmental temperature in which the turbine engine component is disposed or operated.

28. The turbine component of Claim 20, wherein the substrate comprises a turbine nozzle, shroud, shroud hanger, bucket, airfoil, fan blades, pressure balance seal, or a combustor.

29. The turbine component of Claim 20, wherein the diffusion-controlling layer is at a thickness effective to prevent interdiffusion of the shape memory alloy or the shape memory alloy composite with the substrate.

30. The turbine engine component of Claim 20, wherein the shape memory alloy is a component of a composite.

31. The turbine engine component of Claim 30, wherein the composite further comprises at least one hard particulate phase.

32. The turbine engine component of Claim 31, wherein the at least one hard particulate phase comprises a boride particulate, an oxide particulate, a nitride particulate, a carbide particulate, or combinations comprising at least one of the foregoing particulates.

33. The turbine engine component of Claim 30, wherein the composite comprises alternating layers of the shape memory alloy and a metallic or a ceramic layer.

34. The turbine engine component of Claim 33, wherein the metallic layer is selected from the group consisting of Ti, Ni, Co, Ti-based alloys, Ni-based alloys, Co-based alloys, and Fe-based alloys.

35. The turbine engine component of Claim 32, where in the ceramic layer is selected from the group consisting of borides, oxides, nitrides, carbides, TiN, Y_2O_3, and TaC.

36. The turbine engine component of Claim 30, wherein the composite further comprises grains having a grain size less than 2 micrometers.

37. A process for providing an erosion resistant protective structure to a turbine component, comprising:

affixing a diffusion-controlling layer on a region of the turbine component to be protected with the erosion resistant protective structure, wherein the diffusion-controlling layer is selected from a group consisting of pure metals or alloys that do not form brittle and/or low melting phase due to interaction with erosion resistant structure and/or substrate; and

affixing a shape memory alloy on the diffusion-controlling layer, wherein affixing the diffusion-controlling layer, and the shape memory alloy or the shape memory alloy based composite comprises a hot isotactic pressing process at a temperature less than about 950°C and a pressure greater than about 20 ksi.

38. The process according to Claim 37, wherein the temperature is at about 700°C to about 900°C and the pressure is at about 20 ksi to about 40 ksi.

39. The process according to Claim 37, further comprising exposing the turbine component to a process selected from the group consisting of an aging process and a heat treatment process.

40. The process according to Claim 39, wherein the aging process comprises exposing the turbine component to a temperature of about 480°C to about 815°C for a period of up to about 12 hours.

41. The process according to Claim 37, wherein the heat treatment process comprises exposing the turbine component to a temperature of about 815°C to about 1,010°C for a period of up to about 4 hours.

42. The process according to Claim 37, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, ruthenium-niobium based alloys, ruthenium-tantalum based alloys, titanium based alloys, iron-based alloys, or combinations comprising at least one of the foregoing alloys.

43. The process according to Claim 37, wherein the turbine component comprises a turbine nozzle, shroud, shroud hanger, bucket, airfoil, fan blades, pressure balance seal, or a combustor.

44. The process according to Claim 37, wherein the shape memory alloy is a component of a composite.

45. The process according to Claim 44, wherein the composite further comprises at least one hard particulate phase.

46. The process according to Claim 45, wherein the at least one hard particulate phase comprises a boride particulate, an oxide particulate, a nitride particulate, a carbide particulate, or combinations comprising at least one of the foregoing particulates.

47. The process according to Claim 43, wherein the composite comprises alternating layers of the shape memory alloy and a metallic or a ceramic layer.

48. The process according to Claim 47, wherein the metallic layer is selected from the group consisting of Ti, Ni, Co, Ti-based alloys, Ni-based alloys, Co-based alloys, and Fe-based alloys.

49. The process according to Claim 47, where in the ceramic layer is selected from the group consisting of borides, oxides, nitrides, carbides, TiN, Y_2O_3, and TaC.

50. The process according to Claim 44, wherein the composite further comprises grains having a grain size less than 2 micrometers.

51. The process according to Claim 37, wherein the diffusion-controlling layer is a metal selected from the group consisting of Nb, Hf, Ta, and Zr.

52. A process for providing an erosion resistant coating to a turbine component, comprising:

affixing a diffusion-controlling layer on a region of the turbine component to be protected with the erosion resistant protective structure, wherein the diffusion-controlling layer is selected from a group consisting of pure metals or alloys that do not form brittle and/or low melting phase due to interaction with erosion resistant structure and/or substrate; and

affixing a shape memory alloy on the diffusion-controlling layer, wherein affixing the diffusion-controlling layer, and the shape memory alloy or the shape memory alloy based composite comprises co-extruding at a temperature less than about 950°C and an area reduction equal to or greater than 2:1.

53. The process according to Claim 52, wherein the temperature is at about 700°C to about 900°C and the area reduction ratio is at 2:1 to 8:1.

54. The process according to Claim 52, wherein the diffusion-controlling layer is a metal selected from the group consisting of Nb, Hf, Ta, and Zr.

55. The process according to Claim 52, further comprising exposing the turbine component to a process selected from the group consisting of an aging process and a heat treatment process.

56. The process according to Claim 55, wherein the aging process comprises exposing the turbine component to a temperature of about 480°C to about 815°C for a period of up to about 12 hours.

57. The process according to Claim 55, wherein the heat treatment process comprises exposing the turbine component to a temperature of about 815°C to about 1,010°C for a period of up to about 4 hours.

58. The process according to Claim 52, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, ruthenium-niobium based alloys, ruthenium-tantalum based alloys, titanium based alloys, iron-based alloys, or combinations comprising at least one of the foregoing alloys.

59. The process according to Claim 52, wherein the turbine component comprises a turbine nozzle, shroud, shroud hanger, bucket, airfoil, fan blades, pressure balance seal, or a combustor.

60. The process according to Claim 52, wherein the shape memory alloy is a component of a composite.

61. The process according to Claim 60, wherein the composite comprises at least one hard particulate phase.

62. The process according to Claim 61, wherein the at least one hard particulate phase comprises a boride particulate, an oxide particulate, a nitride particulate, a carbide particulate, or combinations comprising at least one of the foregoing particulates.

63. The process according to Claim 60, wherein the composite comprises alternating layers of the shape memory alloy and a metallic or a ceramic layer.

64. The process according to Claim 63, wherein the metallic layer is selected from the group consisting of Ti, Ni, Co, Ti-based alloys, Ni-based alloys, Co-based alloys, and Fe-based alloys.

65. The process according to Claim 63, where in the ceramic layer is selected from the group consisting of borides, oxides, nitrides, carbides, TiN, Y_2O_3, and TaC.

66. The process according to Claim 60, wherein the composite further comprises grains having a grain size less than 2 micrometers.

67. A process for providing an erosion resistant protective structure to a turbine component, comprising:

affixing a diffusion-controlling layer on a region of the turbine component to be protected with the erosion resistant protective structure, wherein the diffusion-controlling layer is selected from a group consisting of pure metals or alloys that do not form brittle and/or low melting phase due to interaction with erosion resistant structure and/or substrate; and

affixing a shape memory alloy or a shape memory alloy based composite on the diffusion-controlling layer, wherein affixing the diffusion-controlling layer, and the shape memory alloy or the shape memory alloy based composite comprises a process selected from the group consisting of brazing, welding, thermally spraying, laser consolidation, plasma transfer arc, hot rolling, cold rolling, ion plasma deposition, forging, explosion welding, fusion welding, friction stir welding, and cladding.

68. An insert for repairing a turbine component, comprising:

a substrate dimensioned to be inserted into a recess formed in a turbine component; and

an erosion resistant protective structure formed on a surface of the substrate, the erosion resistant protective structure comprising a shape memory alloy.

69. The insert of Claim 68, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, ruthenium-niobium based alloys, ruthenium-tantalum based alloys, titanium based alloys, iron-based alloys, or combinations comprising at least one of the foregoing alloys.

70. The insert of Claim 68, wherein the shape memory alloy is a component of a composite.

71. The insert of Claim 70, wherein the composite further comprises at least one hard particulate phase.

72. The insert of Claim 71, wherein the at least one hard particulate phase comprises a boride particulate, an oxide particulate, a nitride particulate, a carbide particulate, or combinations comprising at least one of the foregoing particulates.

73. The insert of Claim 70, wherein the composite comprises alternating layers of the shape memory alloy and a metallic or a ceramic layer.

74. The insert of Claim 73, wherein the metallic layer is selected from the group consisting of Ti, Ni, Co, Ti-based alloys, Ni-based alloys, Co-based alloys, and Fe-based alloys.

75. The insert of Claim 73, wherein the ceramic layer is selected from the group consisting of borides, oxides, nitrides, carbides, TiN, Y_2O_3, and TaC.

76. The insert of Claim 70, wherein the composite further comprises grains having a grain size less than 2 micrometers.

77. The insert of Claim 68, further comprising a diffusion-controlling layer intermediate the substrate surface and the shape memory alloy.

78. The insert of Claim 77, wherein the diffusion-controlling layer is selected from the group consisting of pure metals or alloys that do not form brittle and/or low melting phases due to interaction with the erosion resistant structure and/or substrate.

79. The insert of Claim 77, wherein the diffusion-controlling layer is a metal selected from the group consisting of Nb, Hf, Zr, and Ta.